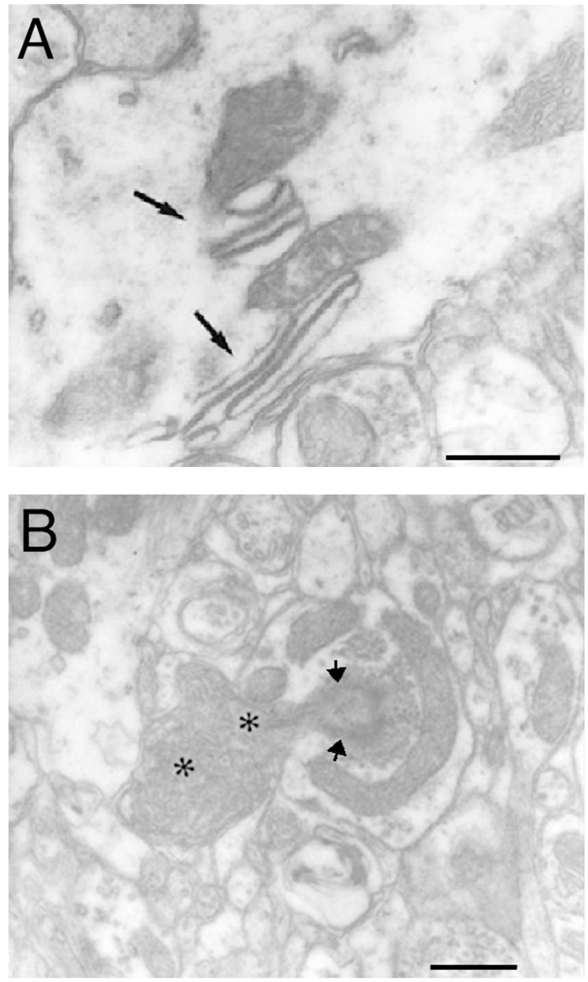
Understanding How Astronauts Adapt to Space and to Earth

Anatomical Studies of Central Vestibular Adaptation

Significant changes take place in the nervous systems of astronauts during and following exposure to microgravity. These changes, particularly in the part of the brain that controls balance, the vestibular system, can cause sensations of rotation, dizziness, and vertigo, as well as space adaptation syndrome. Adaptation to the microgravity environment usually occurs within one week, and a subsequent re-adaptation period of several days is often required upon return to Earth. In order to realize long-term spaceflight, effective countermeasures for these symptoms must be developed.

The structural changes that take place in one of the vestibular regions of the brain (the cerebellar cortex) during the process of adaptation to Earth's gravity remain unclear and are the subject of an experiment being conducted on STS–107 by Dr. Gay Holstein of the Mount Sinai School of Medicine in New York. Using the rat as a model, Dr. Holstein and her team will seek to identify the cellular changes underlying the vestibular changes experienced by astronauts.



Electron micrographs of the cerebellar cortex from a rat after 24 hours of spaceflight. One unusual change observed in the ultrastructure of the Purkinje cells was the presence of extensive enlargements of the cisternal membranes into organelles called lamellar bodies (A, arrows). Panel B illustrates electron-dense degeneration in Purkinje cell dendrites (asterisks). Synaptic contacts with the degenerated cells are indicated by black arrows. The scale bar is 0.5 µm long. These observations will be further studied on STS–107.

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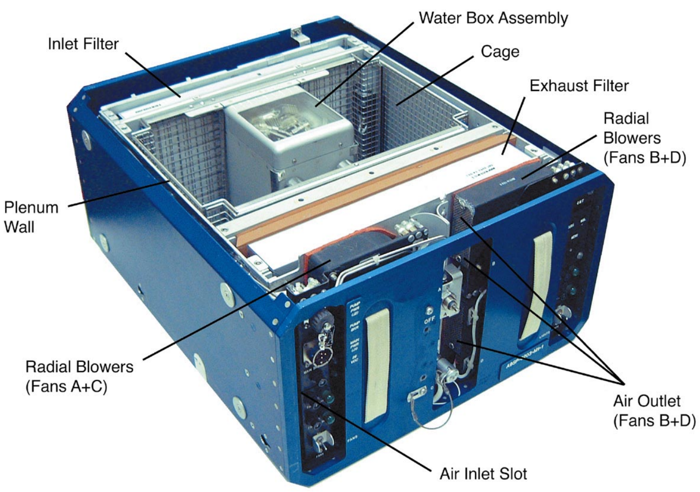
Background Information

Science

For this experiment, five flight and five ground control animals will be housed in two Animal Enclosure Modules (AEMs). The five flight animals will be flown aboard the Shuttle in one AEM, for a total of 16 days. Ground based 72-hour delayed control rats will be housed in the other AEM. Ultrastructural studies will then be carried out using electron microscopy. The results of this experiment will help to identify the cellular bases underlying the vestibular changes experienced by astronauts during periods of adaptation and re-adaptation to altered gravitational forces, and may provide insights for the development of effective pharmacotherapeutic countermeasures.

Science Discipline Supported

This experiment supports NASA's priorities for research aimed at understanding fundamental biological processes in which gravity is known to play a direct role and alleviating problems that may limit astronauts' ability to survive and/or function during prolonged spaceflight.



This experiment is part of the Fundamental Rodent Experiments Supporting Health (FRESH)-02 payload which consists of 13 rats housed in 3 AEMs. The animals, which will be shared among several different investigators, will experience microgravity for 16 days on board the Shuttle *Columbia*. The AEMs have been used successfully on many previous shuttle flights.

Hardware

The AEMs is a rodent habitat that provides ventilation, continuous filtered air flow to control waste and odor, timed lighting, food in the form of foodbars attached to the side of the cage, and a water supply which can be refilled as required. Rodents in the cage compartment of the AEM are not accessible but can be viewed through the clear lexan cover. This also allows for viewing of water level remaining in the AEM water box.

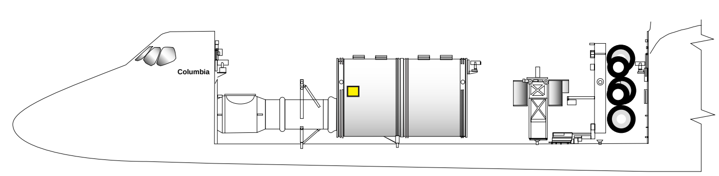
The AEM has been designed for minimum crew interaction and the animals adapt very well to this virtually self-contained system. The only nominal operations required are a daily hardware check, a daily visual animal health check, and periodic water refills.

Earth Benefits and Applications

The results of this experiment will help to identify the cellular bases underlying vestibular changes that occur during periods of adaptation and re-adaptation to different gravitational forces. In that light, the findings may provide insights for the development of effective pharmacotherapeutic countermeasures for vestibular changes during spaceflight. In addition, since the short- and long-term changes in neural structure and connectivity that occur during adaptation to microgravity mimic the neuronal alterations that occur in many progressive neurological disorders such as stroke and Parkinson's Disease, findings from this study using a rat model could offer guidance in the development of strategies for neurorehabilitation and treatment of these disorders.

Previous Results

The results from a previous experiment flown on STS–90 suggest that immediately following exposure to spaceflight, substantial structural reorganization takes place in the regions of the brain involved in controlling balance and equilibrium. Observations of brain tissue obtained after 24 hours of spaceflight indicate that several structural alterations occur in specific regions and cells of the rat brain. These alterations are not apparent in the cage control animals. The primary goal of the present project is to study these ultrastructural alterations in greater detail.



Approximate locations of this payload aboard STS–107.

Picture credits. Holstein (page 1), Ames Research Center (page 2).

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